

We Claim:

1. A method for adaptively adjusting the amount of liquid added to a dishwasher in one or more liquid fill periods in a dishwasher cycle comprising:

activating the dishwasher drain pump to drain liquid from said dishwasher while continuing to operate the dishwasher circulation pump prior to the end of at least one

5 liquid circulation period;

accumulating the time from the start of said drain pump operation until said circulation pump experiences a liquid starvation episode;

comparing said accumulated time period with a predetermined optimum time period for said circulation pump to experience liquid starvation;

10 using the difference between said accumulated time period and said predetermined optimum time period to adjust the amount of liquid added in the next liquid fill period; and

adding said adjusted amount of liquid during the next liquid fill period.

2. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 1 wherein the amount of liquid added in liquid fill periods is adaptively adjusted in more than one liquid fill period, said method further comprising storing said adjusted liquid fill period amount of liquid in an adaptive fill memory in the controller for said
- 5 dishwasher and using said stored adjusted liquid fill period amount of liquid as the basis for adjustment of the next liquid fill period.

3. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 2 wherein the amount of liquid added in an adjusted liquid fill period is increased or decreased by adjusting the duration of the liquid fill period.
4. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 2 wherein the amount of liquid added in an adjusted liquid fill period is increased or decreased by controlling the amount of liquid added using a liquid flow meter.
5. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 2 wherein the first liquid fill period in a dishwasher cycle following an interruption of the power supply for said dishwasher is predetermined to provide sufficient liquid for said circulation pump to operate without experiencing liquid starvation prior to activation of said drain pump under any operating conditions.
6. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 2 wherein said adjusted liquid fill period amount of liquid is stored in non-volatile adaptive fill memory of said controller and wherein the first liquid fill period following an interruption of the power supply for said dishwasher uses said stored adjusted fill time period amount of liquid for said first liquid fill period.
7. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 2 wherein the amount of liquid added in each liquid fill period in said dishwasher cycle is adaptively adjusted.

8. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 1 wherein said circulation pump is deactivated after said circulation pump experiences a liquid starvation episode, and said drain pump is operated for an additional predetermined drain period after said circulation pump is deactivated to complete
5 draining of liquid at the end of said liquid circulation period.
9. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 1 wherein said circulation pump liquid starvation episode is detected by monitoring an operational condition of said circulation pump.
10. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 9 wherein said circulation pump starvation episode is detected by a sudden circulation pump pressure decrease.
11. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 9 wherein said circulation pump starvation episode is detected by a sudden circulation pump speed increase.
12. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 9 wherein said circulation pump starvation episode is detected by a sudden circulation pump motor torque decrease.

13. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 9 wherein said circulation pump starvation episode is detected by a sudden circulation pump motor current decrease.
14. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 9 wherein said circulation pump starvation episode is detected by a sudden circulation pump motor main winding phase lag increase.
15. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 9 wherein said circulation pump starvation episode is detected by a sudden circulation pump motor phase lag increase.
16. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 2 wherein an additional small amount of liquid is added to the stored adjusted liquid fill period amount of liquid for the first fill of a new dishwasher cycle to compensate for evaporation of residual wash liquid in said dishwasher between
5 dishwasher cycles.
17. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 16 wherein a greater additional amount of liquid is added to the stored adjusted liquid fill period amount of liquid for the first fill of a new dishwasher cycle after said dishwasher has not been operated for more than a few days.

18. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 2 wherein an additional small amount of liquid is added to the stored adjusted liquid fill period amount of liquid for the first fill of a new dishwasher cycle to compensate for evaporation of residual wash liquid when the previous dishwasher cycle
5 included a heated drying period.
19. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 1 wherein said adjusted amount of liquid added must be within minimum and maximum limits for the amount of liquid added in a liquid fill period.
20. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 1 wherein absence of a circulation pump liquid starvation episode within a predetermined time following activation of said drain pump infers a drain failure condition and causes the controller for said dishwasher to provide a drain failure
5 indication and stop said dishwasher cycle.
21. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 1 wherein occurrence of a circulation pump liquid starvation episode prior to activating said dishwasher drain pump causes the controller for said dishwasher to infer an abnormal operating condition variable and causes said controller to take one or more
5 actions selected from the group of adding liquid to quell said liquid starvation episodes, shorten the current circulation sub-cycle, institute a predetermined liquid fill for the next fill sub-cycle, add one or more additional fill, circulation and drain sub-cycle sequences to the dishwasher cycle.

22. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 1 wherein said method includes monitoring said circulation pump following addition of rinse-aid material to confirm presence of rinse-aid material by detecting a change in an operational condition of said circulation pump compared to normal operational conditions.

23. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 22 wherein failure to detect presence of rinse-aid material causes the controller for said dishwasher to take one or more actions selected from the group of causing the controller to attempt another addition of rinse-aid material and providing a fill rinse-aid dispenser signal.

24. A method for adaptively adjusting the amount of liquid added to a dishwasher in one or more liquid fill periods in one or more dishwasher cycles each including a plurality of liquid fill periods, a plurality of liquid circulation periods and a plurality of liquid drain periods operated by a controller comprising:

activate the dishwasher drain pump to drain liquid from said dishwasher while continuing to operate the dishwasher circulation pump near the end of at least one liquid circulation period;

monitor operation of the circulation pump to accumulate a circulation pump starvation period beginning with activation of said drain pump and ending when said circulation pump experiences a liquid starvation episode;

compare said circulation pump starvation period with a predetermined optimum time period for said circulation pump to experience liquid starvation to decrease or increase the amount of liquid added to the adaptive liquid fill period amount of liquid stored in said controller depending on whether said circulation pump starvation period is longer or
15 shorter than said predetermined optimum time period;

deactivate said circulation pump after said circulation pump experiences a liquid starvation episode and continue to operate said drain pump to complete draining of said liquid at the end of said liquid circulation period;

store said adjusted adaptive liquid fill period amount of liquid in said controller for
20 the next liquid fill period replacing the previous adaptive liquid fill period amount of liquid; and

implement said adjusted adaptive liquid fill period in the next liquid fill period of said dishwasher.

25. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 24 wherein said circulation pump liquid starvation episode is detected by monitoring a circulation pump operating parameter selected from the group consisting of detecting a sudden decrease in circulation pump pressure, a sudden increase in circulation
5 pump motor speed, a sudden decrease in circulation pump motor torque, a sudden decrease in circulation pump motor current, a sudden increase in circulation pump motor main winding phase lag, or a sudden increase in circulation pump motor total phase lag.

26. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 24 wherein each liquid fill period in each of said dishwasher cycles is adaptively adjusted.
27. The method for adaptively adjusting the amount of liquid added to a dishwasher of claim 24 wherein the circulation pump is allowed to continue to operate for a preset time after detection of said liquid starvation episode.
28. An automatic dishwasher including:
- a circulation pump and motor for circulating liquid in said dishwasher during circulation periods;
 - a drain pump and motor for pumping liquid from said dishwasher during drain periods;
 - a fill valve for controlling flow of liquid into said dishwasher during liquid fill periods;
 - a controller for operating said circulation pump motor and said drain pump motor in one or more dishwashing cycles each having one or more circulation periods, one or more drain periods and one or more liquid fill periods and having an adaptive fill control for determining the amount of liquid added to said dishwasher in said liquid fill periods arranged to operate said fill valve for a preprogrammed liquid fill period or an adaptive liquid fill period; said adaptive fill control comprising:
 - a sensor for detecting when said circulation pump experiences a liquid starvation episode after said drain pump is activated while said circulation pump continues to operate near the end of a circulation period;

a microprocessor arranged to:

accumulate a liquid starvation time period beginning with said drain pump activation and ending when said circulation pump experiences a liquid

20 starvation episode;

compute the sign and magnitude of the difference between said liquid starvation time period and a predetermined optimum time period for said circulation pump to experience liquid starvation;

25 apply an algorithm to said computed difference to adjust the adaptive liquid fill period stored in an adaptive fill memory to increase or decrease the amount of liquid added in the previous liquid fill period based on said sign and difference between said liquid starvation time period and said predetermined optimum time period; and

30 store said adjusted adaptive liquid fill period in said adaptive fill memory for use in the next liquid fill period.

29. The dishwasher of claim 28 wherein said sensor for detecting when said circulation pump experiences a liquid starvation episode is selected from the group consisting of a pressure sensor for detecting a sudden decrease in circulation pump pressure, a tachometer for detecting a sudden increase in circulation pump motor speed, a power
- 5 sensor for detecting a sudden decrease in circulation pump motor torque, a current sensor for detecting a sudden decrease in circulation pump motor current, a saturating ferrite transformer sensor for detecting a sudden increase in circulation pump motor main winding phase lag, or a saturating ferrite transformer sensor for detecting a sudden increase in circulation pump motor total phase lag.

10

30. The dishwasher of claim 28 wherein said adaptive control applies said preprogrammed liquid fill period for the first liquid fill period in a dishwasher cycle following an interruption of the power supply to said dishwasher, and applies an adjusted adaptive liquid fill period for all liquid fill periods after a first liquid fill period after a power interruption to said dishwasher.

5

31. The dishwasher of claim 28 wherein said adaptive fill memory is a non-volatile memory for storing said adjusted liquid fill period and said adaptive fill control applies said stored adjusted adaptive liquid fill period for the first liquid fill period after a power interruption to said dishwasher.

5

32. The dishwasher of claim 28 wherein said controller includes a drain failure indicator and wherein said microprocessor is arranged to infer a drain failure condition from the absence of a circulation pump liquid starvation episode within a predetermined time following activation of said drain pump.

33. The dishwasher of claim 28 wherein said controller is arranged to detect liquid starvation episodes prior to activation of said drain pump while said circulation pump is operating and to infer an abnormal operating condition variable and to cause said controller to take one or more actions selected from the group of adding liquid to quell said liquid starvation episodes, shorten the current circulation sub-cycle, institute a

5

predetermined liquid fill for the next fill sub-cycle, add one or more additional fill, circulation and drain sub-cycle sequences to the dishwasher cycle

34. The dishwasher of claim 28 wherein said controller is arranged to cause a rinse-aid dispenser to dose rinse-aid material in connection with a rinse sub-cycle and said controller and said sensor are arranged to monitor circulation pump operating conditions following addition of said rinse-aid material to confirm the presence of rinse-aid material by detecting a change in a circulation pump operating parameter selected from the group of a decrease in circulation pump pressure, an increase in circulation pump motor speed, a decrease in circulation pump motor torque, a decrease in circulation pump motor current, an increase in circulation pump motor main winding phase lag, or an increase in circulation pump motor total phase lag compared to normal.

10

35. The dishwasher of claim 34 wherein said controller is arranged to take one or more actions upon failure to detect presence of rinse-aid material selected from the group of causing the controller to attempt another addition of rinse-aid material and providing a fill rinse-aid dispenser signal.

36. The dishwasher of claim 28 wherein said adaptive fill control controls the amount of liquid added in a liquid fill period by controlling the length of time said fill valve is operated.

37. The dishwasher of claim 28 wherein said dishwasher includes a liquid flow meter connected in liquid circuit with said fill valve arranged to provide a signal to said microprocessor representing the amount of liquid that has passed through said flow meter and said adaptive fill control controls the amount of liquid added in a liquid fill period by operating said fill valve until said adjusted amount of liquid has been added to said dishwasher.
- 5